Pollution Prevention at Los Alamos National Laboratory

Heat Exchanger Cleaning

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The Challenge: Heat exchanger cleaning generates a significant amount of waste that is currently managed through TA –54 and sent offsite for disposal. The cleaning process uses approximately 200 gallons of cleaning solution and 300-600 gallons of water to clean, flush, and rinse the system. This results, on average, in approximately 2,500 kg of waste generation with each cleaning. Cleaning wastes are reported as RCRA Hazardous or as NM Special Wastes and contribute up to 10 mt per year to the Laboratory's hazardous waste generation amounts.

The cleaning process uses Ammonium Bifluoride (ABF) to clean silica scale from heat exchangers, chillers, and piping. Hydrochloric acid is used to initiate the cleaning action of the Ammonium Bifluoride. Rust inhibitors are added to the cleaning solution to reduce corrosion of base metals from equipment, although it is not clear if this is a Laboratory-wide practice. In the past, the Ammonium Bifluoride cleaner contained small amounts of arsenic as a by-product of the manufacturing process that rendered the waste RCRA-hazardous. A new manufacturer of Ammonium Bifluoride cleaner was identified and is used routinely to clean heat exchangers. This new source does not have arsenic contamination as a by-product and therefore the RCRA-hazardous issues have been eliminated. However, some waste management coordinators continue to characterize this waste as RCRA hazardous, assuming that the cleaner still contains arsenic. Once the chemical cleaning is completed, large amounts of water are used to rinse the system; this water is also managed as RCRA Hazardous or NM Special Waste, regardless of levels of concentration of residual cleaning chemicals.

Other issues identified through the course of this evaluation included cooling tower/heat exchanger maintenance, chemical management and controls. Water in the Los Alamos area has high silica content that contributes to the potential for silica scale build-up on heat exchangers. Conductivity measurements and other controls determine water treatment regimes that slow scale build-up on heat exchangers. Cooling towers/heat exchangers rely on water from wells managed by Los Alamos County and must contend with altering water wells that reduce predictability of water mineral content and complicate water control and treatment. Facility managers may not understand overall preventive maintenance needs for cooling towers/heat exchangers; this lack of understanding, as well as competing priorities may result in less than optimal maintenance. This may lead to scale build-up and ultimately a systems shutdown. These factors affect how often heat exchangers require cleaning. Improvements in these areas may yield the best source reduction opportunities in the heat exchanger cleaning process.

JCNNM conducts some heat exchanger cleaning at the Laboratory; however, other contractors also provide this service at many FM's. It is not clear if standard procedures are followed by all cleaning contractors.

This paper will discuss how the JCNNM/ESO team used the following tools to address the issues involved with excess chemicals:

- Determining opportunities in the current process using process maps.
- Rank ordering of the opportunities to improve the process using Pareto analysis and activity based costing.
- Determining the root cause of the selected opportunity using a cause and effect (fishbone) diagram.
- Posing a consensus problem statement for generating process alternatives.
- Generating process alternatives.
- Selecting alternatives using a forced pairs comparison.
- Developing a formal action plan for the selected alternative.

The Green Zia Team included the following participants:

- Jim Stanton, JCNNM
- Lewis Mondragon, JCNNM
- Patricia Vardano-Charles, LANL-ESO
- Patricia Gallagher, LANL-ESO
- Bryan Carlson, LANL-ESO

This report was reviewed by D'Ann Bretzke, ESO and Bill Radzinski, FWO.

Process Mapping

Process maps were developed for the major processes and Activity-Based Costing included all relevant costs for activities identified for all the mapped processes. The overview map illustrates the overall processes of cooling tower operation, heat exchanger cleaning and waste management. Three detailed process maps illustrating the job scoping, cooling tower operation and the heat exchanger cleaning operations are included in this report because they illustrate the most relevant process steps addressed in this evaluation.

Figure 1.

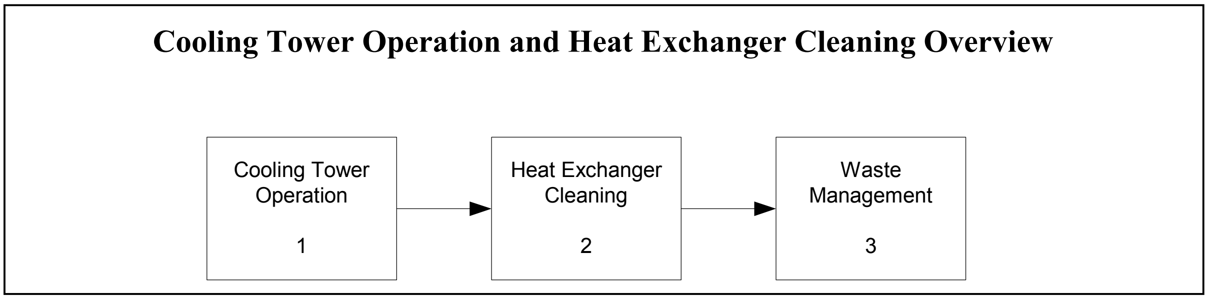


Figure 2.

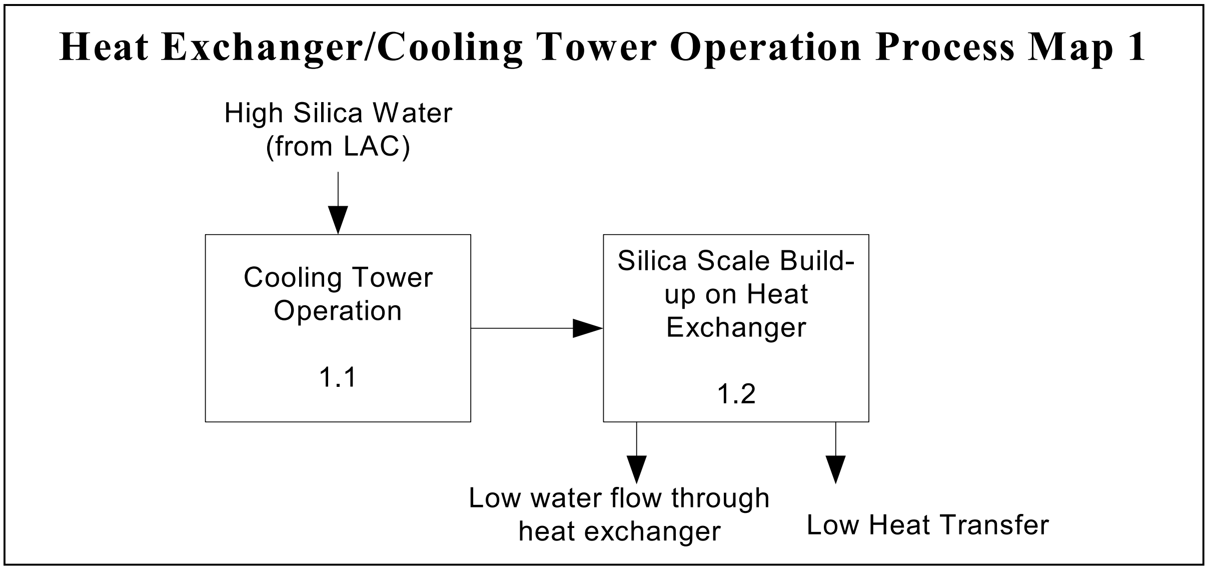


Figure 3.

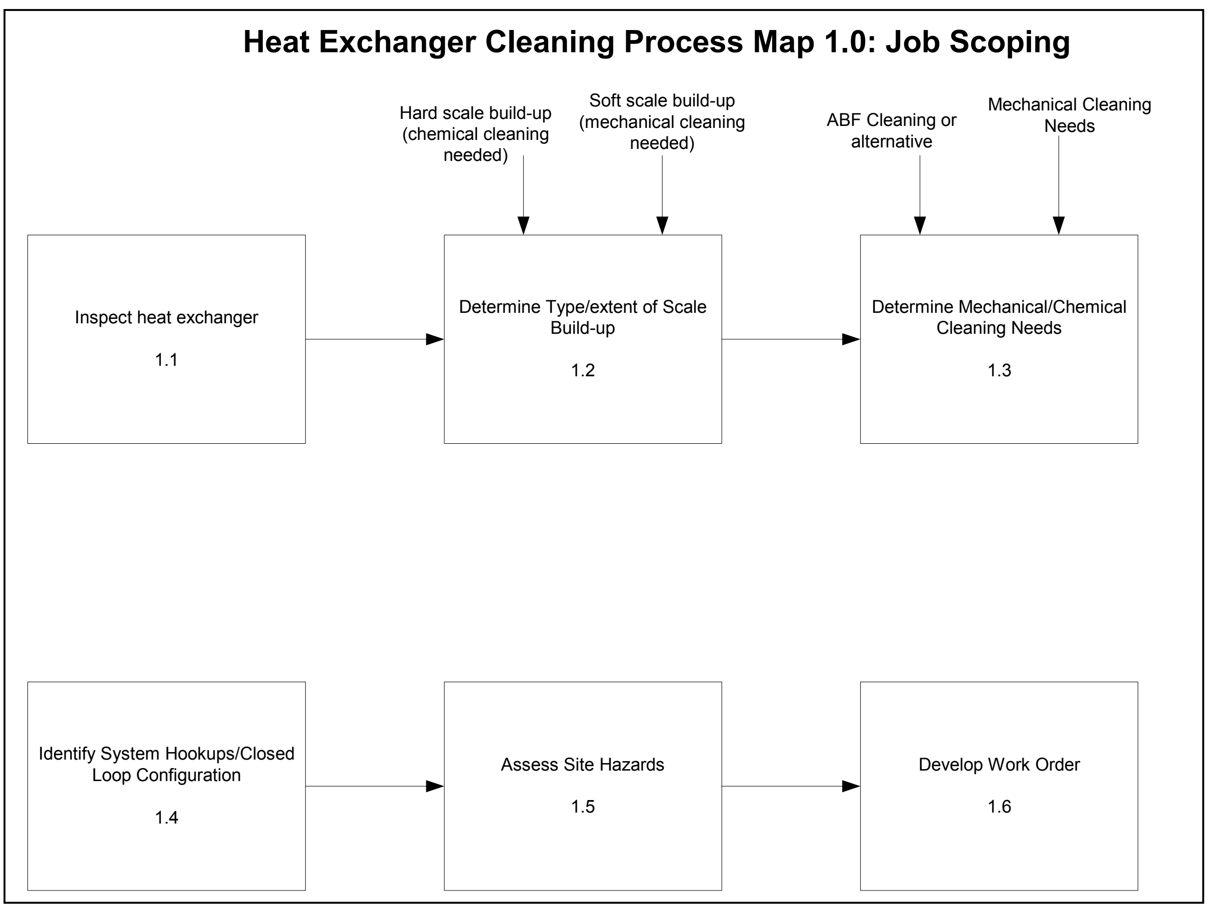
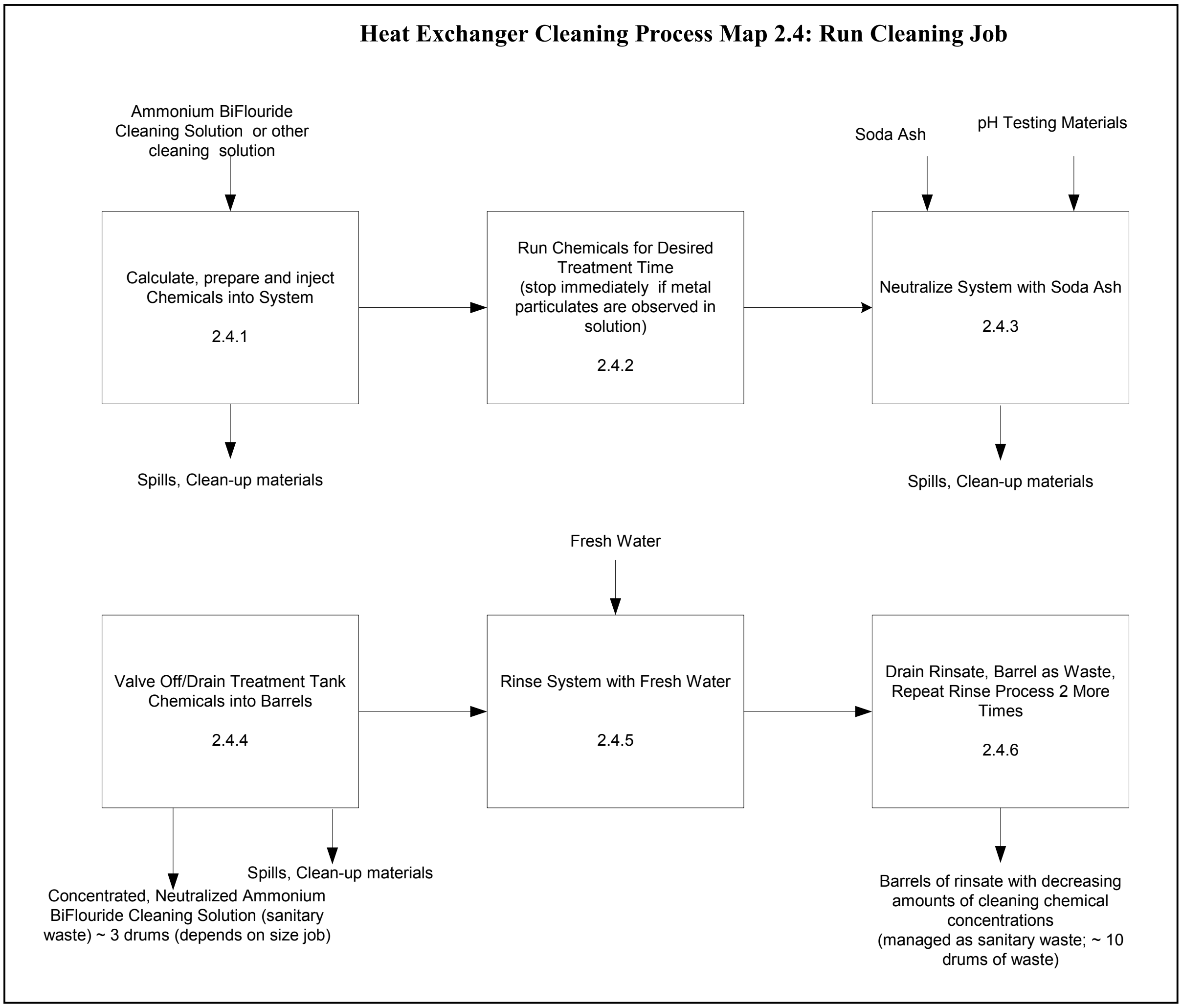


Figure 4



Rank Ordering of Opportunities

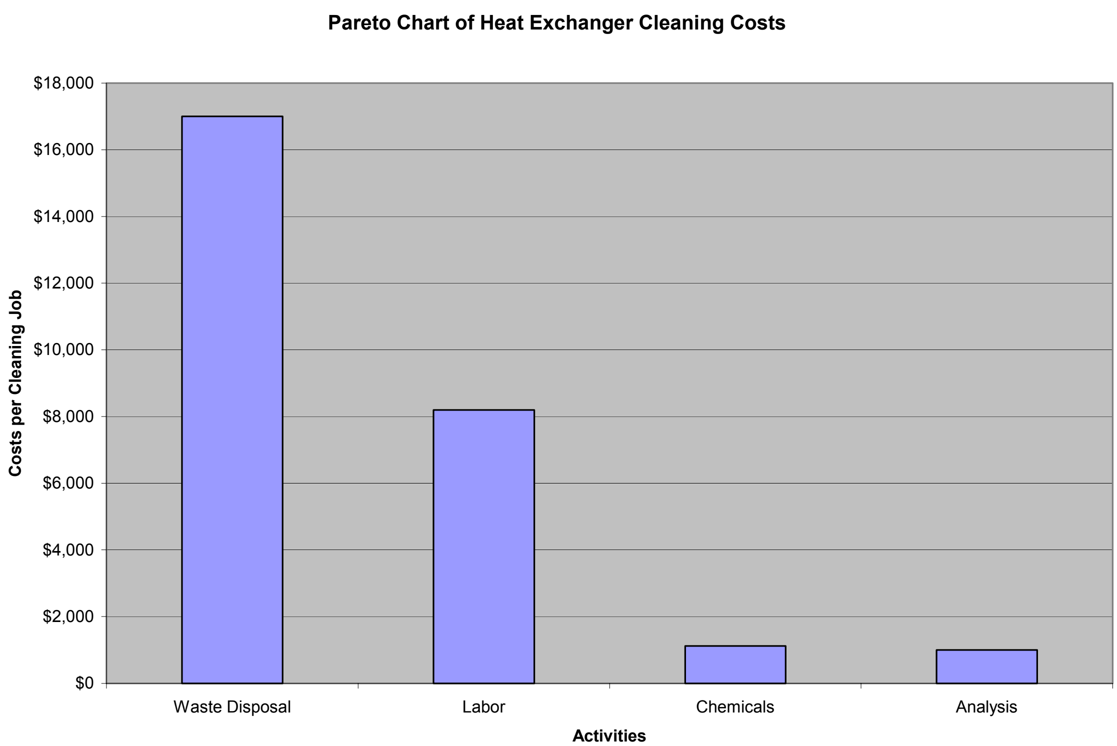
Activity based costing was developed for the cleaning process. The initial cost estimate for a cleaning job was $5,000. Activity based costing determined that the actual cost of cleaning and waste management for a single heat exchanger job was approximately $27,000.

Heat Exchanger Cleaning	
Job Scoping/Preparation/Implementation	
Labor JCNNM	$5,000
Labor LANL	$800
Chemicals	$1,120
Waste Handling and Management	
Labor: WMC	$2,400
Analysis	$1,000
Fees	$17,000
Total	**$27,320**

Waste management costs were the highest cost identified. Waste management costs include record keeping, paperwork, analysis and waste disposal costs.

A Pareto Chart was prepared to identify the costs of the heat exchanger cleaning process and is depicted in Figure 5.

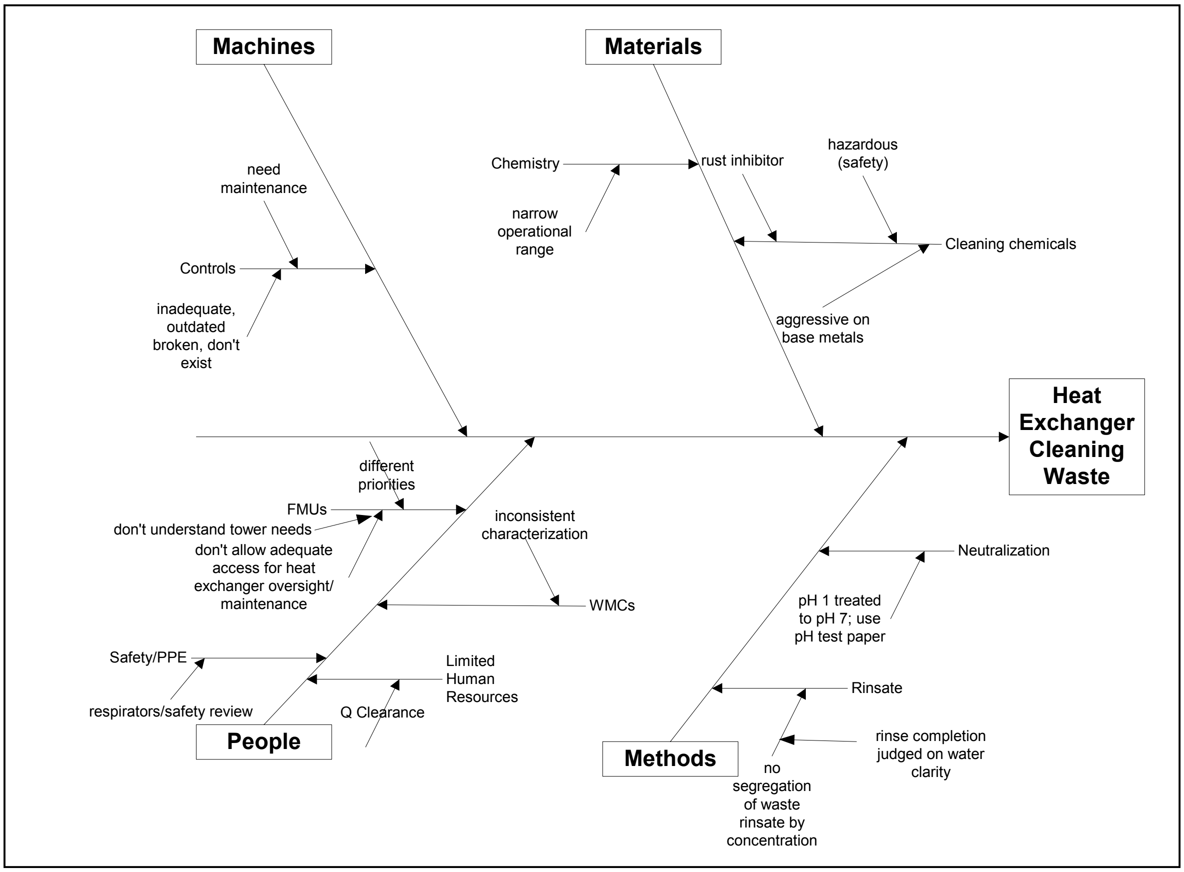
Figure 5



Root Cause Analysis and Statement of Problem

The team examined the issues associated with waste generation with a cause and effect diagram to identify potential causes of the problem. The diagram is presented in Figure 6.

Figure 6



The following is a detailed list and description of the items present on the cause and effect diagram.

- Controls: Controls for monitoring and treating water may not exist, are broken, outdated or poorly maintained.
- Chemistry: High silica water and existing controls, even with scale dispersant chemicals, only have a narrow operational range before scale build-up begins. Fluctuation in silica content of source water complicates this issue.
- Cleaning Chemicals and Methods: The Ammonium Bifluoride cleaner is hazardous in terms of safety and is an aggressive cleaner that may corrode base metals. Corrosion may damage equipment, reducing its life. Also, mechanical

cleaning methods and use of less-hazardous cleaning chemicals are not consistently evaluated as an alternative to ABF chemicals.

- Facility Management staff: Facility Managers may not understand the importance of regular maintenance and general maintenance issues. Competing priorities may result in inadequate maintenance.
- Human Resources: Q-clearances are required for certain technical areas that create specific staffing issues.
- Waste Management Coordinators: WMCs sometimes mischaracterize wastes as RCRA, thinking that cleaner still contains trace amounts of arsenic.
- Rinsing Process: Rinsing is judged to be complete based on clarity of rinsate. This may be accurate but no testing has been done to prove that this is an adequate test of cleanliness. Also, the first rinse cycle contains the most concentrated amount of chemicals. Subsequent rinses (3 or more) have less chemical load and may be benign enough to be disposed through the Sanitary Wastewater System. If necessary, the rinsate could be run through the mobile pretreatment unit prior to disposal at the Sanitary Wastewater System (only if the requestor of the unit knows why it can not meet the SWS Waste Acceptance Criteria and only if the pre-treatment unit has a treatment protocol in place to address the contaminant).

Team members were requested to review the results of the root cause analysis and prepare a statement that captured what each person thought was the major issues involved in the generation of excess chemicals requiring disposal. The following consensus statement of the problem was prepared.

Poor chemical management and controls lead to premature scale build-up on heat exchangers, resulting in the need for cleaning. Inefficient waste management techniques result in 60% more drummed waste than necessary.

Development of Alternatives

A brain-storming tool was used by the team to generate possible alternatives to the two problems identified. The alternatives that resulted from this activity are as follows:

1. Improve heat exchanger operation and chemical management, including controls and chemical dispersants.
2. Segregate rinsate by concentration; send dilute rinsate to the Sanitary Wastewater System.
3. Educate WMCs on waste characterization.
4. Improve outreach/educate FMs to help them understand existing operating standards.
5. Review cleaning procedures, revise if necessary and deploy throughout the Laboratory.
6. Treat lower concentration rinsate with mobile pretreatment unit, if possible or if necessary.
7. Increase staff availability to do tower maintenance (FM issue).

8. Centralize cooling tower/heat exchanger oversight through centralized control systems
9. Use a less-hazardous heat exchanger cleaner.
10. Monitor county wells for silica content/continuous monitors on potable water supply; this information would be used to adjust water treatment chemistry.
11. Replace outdated chillers with continuous cleaning systems
12. Minimize rinse water through use of evaporation/reverse osmosis systems.

Selecting an Alternative

The team used a forced pair comparison to select alternatives that should be implemented in the near term. The final ordering was reviewed by the group and is presented below. The alternatives were broken down into two categories: Preventive Maintenance and Waste Management.

Preventive Maintenance

1. Improve cooling tower/heat exchanger chemical management and controls.
2. Develop specification to include self-cleaning chillers for new cooling towers.
3. Improve outreach/educate to FMs to help them understand maintenance needs.
4. Centralize cooling tower oversight through centralized control systems.
5. Monitor county wells for silica content/continuous monitors on potable water supply and devise system to make chemical treatment adjustments accordingly.

Waste Management

1. Segregate rinsate by concentration; treat lower concentration rinsate with mobile pretreatment unit, send to the Sanitary Wastewater System.
2. Educate WMCs on waste characterization.
3. Minimize rinse water use through use of evaporation/ reverse osmosis systems.
4. Use a less-hazardous heat exchanger cleaner.

Action Plan

The team decided to implement the top two alternatives for each category at this time.

Action Item Preventive Maintenance	**Organization**	**Due Date**	**Comments**
Develop a plan to address control system needs.	ESO	3/02	
Develop funding proposal for upgrading priority tower(s).	FWO/ESO	10/01	GSAF funding proposal
Develop specification for self-cleaning chillers for new cooling towers.	FWO/ESO	3/02	

Action Item **Waste Management**	**Organization**	**Due Date**	**Comments**
Develop cleaning and waste management procedures to reduce waste.	FWO/JCNNM/ ESO	1/02	